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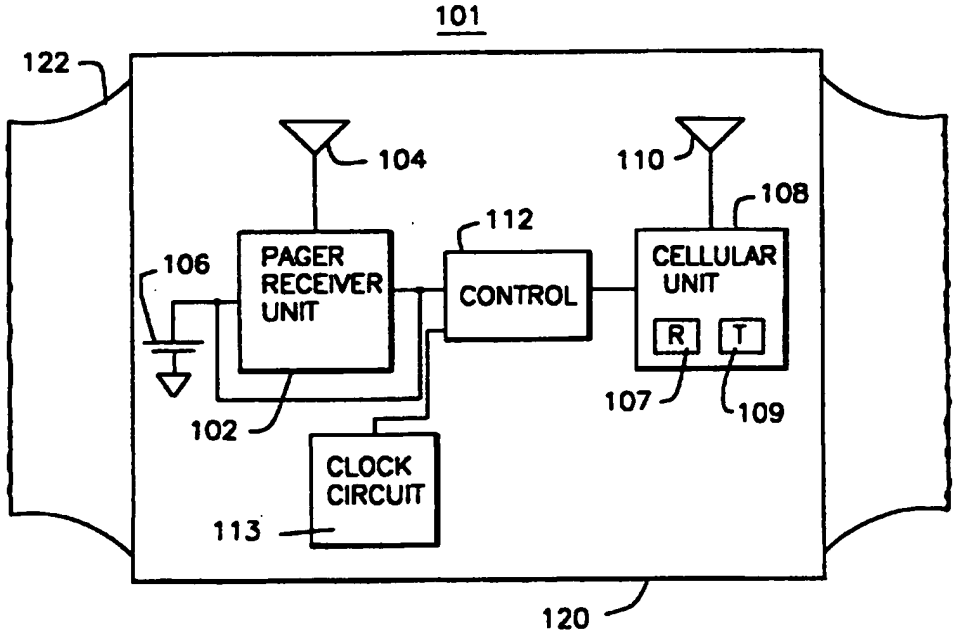

(57) Abstract

A system and device for locating which utilizes cellular technology. The remote pager/cellular device (101) comprises a receiver (102) which receives a pager signal (211) independently of the cellular network. A cellular transmitter (109) is activated in response to such activation signal (211) and provides a cellular signal (213) which is received by the cellular network. The cellular signal (213) can be used to locate the device (101). The cellular transmitting portion (109) is only active when needed, so that the power supply is conserved.

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DESCRIPTION

LOCATING DEVICE AND SYSTEM USING CELLULAR TECHNOLOGIES

TECHNICAL FIELD

The present invention relates generally to a system and device for locating objects such as people, animals or inanimate objects.

BACKGROUND ART

The need to protect children in society has recently taken on a new and growing importance. More and more families have both parents work, and therefore leave their children in the care of others or sometimes home alone. Children can no longer be constantly watched by parents or a guardian. At the same time, child abductions are on the rise. As the number of unattended children increases in this country and world-wide, the likelihood that a child will be abducted becomes greater. To help combat against this crime and aid parents in protecting their children, a device is needed that can be worn by a child which can be easily located to ensure the child's safe return if kidnapped or lost.

A device for tracking a child has been previously disclosed. United States Patent No. 5,289,163 ('163) discloses a child positioning and monitoring device. This device attaches to a child and generates a signal if the child wanders more than a pre-selected distance from the monitoring device. The parent can then use a radio monitor to detect the signal generated from the device indicating the direction in which the child is located. The monitoring system in the '163 patent has only a limited range and is adapted for use only with radio signals. The radio transmitter in the '163 patent is normally used for tracking within only a few miles at the most. If a child is abducted, the abductor may take the child far away from the place of abduction before the parents

or police know the child is missing, and the device disclosed in the '163 patent is not able to track the child at greater distances when required.

There are other needs to track children and other persons. Children or adults can be lost in busy theme parks or when traveling in a car that has broken down with no means of communication. Tracking devices are also needed for elderly or mentally ill people who are lost and confused about their location, and for tracking prisoners or parolees. Device for tracking animals, and for tracking valuable inanimate items from long distances are also needed. For example stolen cars or electronic equipment are often moved out-of-state quickly creating a need to locate them rapidly before they are re-sold or destroyed. There were 1,300,000 stolen vehicles in 1994, a statistic which underscores the need for a reliable tracking device. Moreover, there is also a need to track wildlife animals over large distances for scientific purposes and wildlife conservation.

One possible way to locate a remote device attached to a person or object of value is with the use of cellular technology. Cellular phones are common today that make telephone calls by transmitting cellular signals to cellular stations. Cellular technology can be used to locate a cellular phone as being within a specified geographic area corresponding to a cellular transmitter/receiver site. Current technology can also locate cellular phones using triangulation between at least three cellular sites. However, the triangulation process requires receiving and processing equipment which is in addition to that normally present in a cellular site. One such system of locating cellular phones is disclosed in United States Patent No. 5,327,144 entitled "Cellular Telephone Location System" invented by *Stilp et al.*

One major disadvantage of cellular technology is that a typical cellular device draws substantial power whenever it is on, and drains the battery rapidly. This is due in part to the requirement to transmit periodic cellular control signals even when no call is in progress to identify the telephone to the cellular system. A conventional cellular phone including a battery supply sufficient for normal operation over a period of many hours would be too large and cumbersome to be worn by a small child or carried conveniently by an adult. Stated another way, a cellular telephone operating continuously would require frequent battery changes, rendering the system impractical.

An alternative system that receives transmitted signals is a pager system. Pager systems are common and normally include a remote device that receives "pager" signals generated from a central transmitter or a satellite orbiting the earth. Pager systems have extensive range, and a person can receive a "page" with his remote receiver when located almost anywhere in the country and soon anywhere in the world. The pager device receives a signal including data representing a short message or telephone number for the pager owner to call. A pager device may or may not be able to transmit a signal itself; the more compact pagers are adapted to receive messages only. A paging service using such receive-only pagers cannot confirm if the signal was actually received by the pager device, but only transmits the signal in the areas designated by the user. The power drain by operating a pager device is much less than a cellular phone because there is not need to transmit any signal from the pager device while the device is idle. However, a receiver-only pager cannot be tracked.

Thus, prior to the present invention, there have been needs for improvements in locating devices and methods.

DISCLOSURE OF THE INVENTION

One aspect of the invention provides a device for locating an object, such as a person, animal or inanimate object, within the service area of a cellular communications network of the type having a service area divided into a plurality of geographical cells and having a base station within each cell. The device according to this aspect of the invention includes transmitting means for transmitting a radio signal compatible with the cellular communications network to one of the base stations such that the transmitted signal identifies the object. The transmitting means is normally inactive. The device further includes activating means for activating the transmitting means in response to an activation signal provided independently of said cellular network, said activation means being normally active for receipt of said activation signal. The activation means may include activation receiving means for receiving a radio activation signal from a radio transmitter separate from said cellular telephone network, said receiving means being normally active. For example, the receiving means may be adapted to receive the activation signal from a satellite or from a transmitter of a paging network. Preferably, the activation receiving means is adapted to receive a signal from a wide-area transmitter, covering many geographic cells of the cellular network. The radio activation signal may be sent in response to a location request. For example, where the device is used on a child, the radio activation signal can be sent in response to a request from the parent or guardian of the child.

Because the device can be activated independently of the cellular communications network, there is no need for the device to remain in communication with the cellular network during normal operation, in absence of the activation signal. The transmitting means remains inactive during normal operation, and therefore does not draw power. During normal operation, the device only uses the minimal power required to operate the receiver. Therefore, the device can use a self-contained power supply such as a battery or batteries of reasonable size, or means for deriving power from the body of a person or animal. The ability to use a small self-contained power supply is particularly important where the device is to be carried by a person, and especially so where the device is to be carried by a child or on a small object. Preferably, the device, including the power supply, can be contained in a housing having volumes of about 200 cm^3 or less, more preferably about 100 cm^3 or less.

Because the device can be activated independently of the cellular communications network, and because the transmitter means is normally inactive, the device in its inactive state does not impose any overhead on the cellular network. There is no need for the cellular network to keep track of the location of the device while the transmitter is inactive. By contrast, a conventional cellular transceiver is continually tracked by computers at the mobile telephone switching office or "MTSO". The computers retain records of the cell locations of all active transceivers, and use these records to direct incoming calls to the appropriate cells. The device according to this aspect of the invention does not add to the tracking load on the MTSO computers when the transmitter is inactive. Moreover, while the transmitter is inactive, the device does not emit a

locating signal. Thus, the device does not impair the privacy of a person wearing it unless it is activated.

The transmitter means on the device preferably is compatible with an existing cellular communications network. Many cellular networks, such as cellular telephone networks operating according to the AMPS protocol, use a forward control channel to broadcast control signals conveying information such as the identity of a cell and timing information which allows a remote device such as a cellular telephone to establish communication in accordance with the multiplexing protocol used by the system. The device may include control channel receiver means for receiving the forward control channel, and the transmitter means desirably are arranged to operate in accordance with the information received by the control channel receiver means. Most preferably, the control channel receiver means is normally inactive, and the activation means is arranged to activate the control channel receiver means responsive to the activation signal. The transmitter means and control channel receiver means, when activated, desirably function in the same manner as the corresponding components of a cellular telephone, and allow the device to establish communication with the cellular network in the same way as a "roaming" cellular telephone. The cellular network need not be modified or especially prepared in any manner.

In addition to or in lieu of the receiver means, the activation means may include means for detecting movement of the device and providing the activation signal upon such movement. Alternatively or additionally, the activation means may include means for detecting passage of the device out of a predetermined area and providing said activation signal upon such passage. The passage detection means may include means for detecting electromagnetic radiation

at a boundary of the predetermined area, such as at a doorway of a building where the object is housed. Thus, the device is activated automatically, whenever the object is moved from its assigned location.

The device may further include attaching means operative to attach said transmitting means, said activating means and the self-contained power supply to the body of a person or animal. The attaching means may include a housing having a biocompatable exterior surface so that the housing can be implanted in the body of a person or animal. In this case, the device may be provided with non-invasive recharge means, such as an induction coil or capacitive coupling device to allow recharging of a battery contained in the implanted housing without breaking the skin of the person or animal.

Alternatively, the attaching means may include a band, loop or other fastener for securing the housing to the exterior of the object to be monitored. The activation means may include means for detecting detachment of said housing from the object and providing said activation signal in response to said detachment. Where the device is attached to a vehicle, the activation means may include means for providing the activation signal in response to unauthorized movement of said vehicle.

The activation means may further include a "panic" switch on the device and may be arranged to provide the activation signal in response to actuation of the switch. Thus, when the device is worn by a person, such person can initiate the location process voluntarily, as when the person is threatened or abducted.

Once the transmitter means have been activated, and the device has established communication with the cellular communications network, the device can be located by operation of the cellular

communications network or by "homing" techniques or other techniques which do not require any position-finding capability in the device carried by the object to be located. Thus, the device according to this aspect of the present invention can take advantage of the "built-in" locating capability of certain cellular networks. To facilitate such location, the device may include a homing signal transmitter for sending a homing radio signal in addition to the cellular communications signal. Alternatively, the device may further comprise means for determining data representative of a geographical area within which said object is located, as, for example, a global positioning system ("GPS") receiver and the transmitting means may encode said data onto the transmitted cellular communications signal. Any such location-determining device desirably is normally inactive and is activated in response to the activation signal.

Further aspects of the present invention provide methods of determining the location of an object within the service area of a cellular communications network, said service area being divided into a plurality of geographical cells, said network comprising a base station within each of said geographical cells. Methods according to this aspect of the invention desirably include the steps of placing a radio transmitter on the object, said radio transmitter being normally inactive; providing an activation signal independently of said cellular communications network; in response to said activation signal, activating said transmitter to transmit a signal identifying said object compatible with said cellular communications network to one of said base stations; receiving said signal from said transmitter through at least one of said base stations; and determining said geographical location of said object at least in part based upon the

received signal. As discussed above in connection with the apparatus, the step of providing the activation signal may include the step of broadcasting a radio activation signal, and the step of activating said transmitter may include the steps of operating a radio receiver on said object, receiving said radio activation signal at said receiver and activating said transmitter upon receipt of said radio activation signal. The activation radio receiver on the object need not be operated continuously; it may be operated on a preselected duty cycle so that said receiver is on for at least some portion of every hour, and more preferably for at least some time every few minutes.

As discussed above, the radio activation signal can be broadcasting from a satellite in earth orbit, or from a paging network. These steps may employ existing, publicly available communication facilities. The activation signal preferably includes an address code specifying one device, or a group of devices, to be activated. The locating system thus can provide immediate activation of the device anywhere within the range of the paging system and cellular system.

BRIEF DESCRIPTION OF THE DRAWINGS

Further objects, features and advantages of the invention will become apparent from the following detailed description taken in conjunction with the accompanying figures showing a preferred embodiment of the invention, on which:

Fig. 1 is a block diagram of a device in accordance with one embodiment of the invention;

Fig. 2 is a diagram of a system using the device of Fig. 1;

Fig. 3 is a block diagram of a device in accordance with a further embodiment of the invention, having additional features;

Fig. 4A is a depiction of the device of Fig. 3 attached to a bracelet.

Fig. 4B is a further depiction of the device of Fig. 3 showing an anti-tampering feature.

Fig. 5 is a diagrammatic perspective view depicting a device in accordance with a further embodiment of the invention.

Fig. 6 is a diagrammatic view depicting a device in accordance with another embodiment of the invention.

Fig. 7 is a diagrammatic perspective view depicting a device in accordance with yet another embodiment of the invention.

BEST MODE OF CARRYING OUT INVENTION

A device 101 in accordance with one embodiment of the invention comprises a an activation receiver unit 102, also referred to as a pager receiver, electrically connected to an antenna 104 and a self contained power supply or battery 106. The device further includes a cellular transceiver unit 108 including a transmitting portion 109 and a forward control receiver portion 107, both cellular portions 107 and 109 being electrically connected to a cellular antenna 110. The device further includes a control circuit 112, which desirably includes a relay, solid state switch or other signal-responsive switching device and a clock circuit 113. Control circuit 112 is electrically connected to cellular transceiver unit 108 and to power source 106 and is also electrically connected to pager receiver unit 102 and clock circuit 113. The aforesaid components are mounted in a housing 120, diagrammatically indicated in Fig. 1. The housing is equipped with a bracelet 122 adapted to hold the housing on the wrist or ankle of a person.

Activation receiver unit 102 is of conventional design and receives "pager" signals transmitted from a pager transmitter through antenna 104. The pager receiver may be arranged to operate according to any common paging signal protocol

of the type used by publicly-accessible, common carrier paging systems. For example, receiver 102 may be arranged to operate according to the POCSAG protocol used by certain common carrier paging systems. Such common-carrier protocols typically provide for transmission of an address or "tag" encoded in each message designating a particular receiver as the target for the message. Pager receiver unit 102 is assigned an unique identification tag which allows the receiver to determine if the pager signal received is meant to activate that particular device by checking the incoming pager signal for that tag. Activation receiver unit 102 operates continuously. The activation receiver unit provides an activation signal to control circuit 112 only if an incoming pager signal contains the correct address, matching the identification tag associated with the particular device 101. Incoming pager signals which bear other addresses have no effect. Pager receiver unit 102 requires only sufficient conventional circuitry for receiving the pager signal, *i.e.*, determining an identification match and providing the activation signal to control circuit 112. Pager receiver unit 102 does not require any display means to display a phone number or message as provided in conventional pagers. Pager receiver unit 102 also does not require a sound generator, vibrator means or buttons to be pressed as with a conventional pager. Accordingly, it can be reduced in size and cost from a conventional pager. It is not necessary for the pager receiver unit 102 to be large enough to be hand-held by an operator as with conventional pagers.

Cellular transceiver unit 108 is connected to cellular antenna 110 for receiving and transmitting cellular signals. Cellular transceiver unit includes certain elements normally used in cellular communications devices such as cellular telephones.

Cellular transceiver unit 108 includes a forward control receiver portion 107 for receiving cellular forward control channel signals. According to common cellular communications protocols, such as the AMPS cellular telephone protocol, each cell site continually broadcasts forward control signals which include a site identification code, and which also include signals specifying parameters for use in responsive signals from cellular communications devices . For example, the forward control signals typically specify the frequencies of other channels used by the particular cell for voice message transmission. In a time-division multiplex system, the forward control signals may also provide information specifying the time slots available for use. When cellular unit 108 is activated, receiver portion 107 will scan all of the forward control channels which are in use by the various cell sites. The transceiver unit then identifies the closest cellular site by comparing signal strengths of the forward control channel signals generated by each cellular site, and selects this cell. Once the forward control channel of a particular cell is selected, receiver 107 receives the signal on such channel and extracts the information about voice channel frequencies and other communication parameters for use with the particular cell. Forward control receiver 107 will then provide the cellular site identification code of the closest site to transmitter portion 109.

Transmitter portion 109 is arranged to transmit the cellular site identification code and its own device identification tag to the selected cell site as part of a message bearing a pre-selected telephone number as a telephone to be called. The format of the message is identical to the format of an ordinary cellular telephone call initiation message sent by a "roaming" cellular telephone.

The circuitry of cellular transceiver unit 108 may be of generally conventional design as used in cellular communications devices. However, the transceiver does not require many of the components of a cellular telephone, such as keypad switches, microphone, headphone or audio amplification. Therefore, the circuit configuration can be almost entirely contained in an integrated circuit and be much smaller and cheaper than in a conventional cellular phone. While a conventional cellular phone must be large enough to be operable by a person, cellular unit 108 can be much smaller.

Control circuit 112 is arranged to control cellular transceiver unit 108, and to maintain the transceiver unit in a normally inactive condition. As illustrated, the control circuit is connected between the power input of the transceiver unit and power source 106. Thus, the control circuit normally maintains the transceiver disconnected from the power source, and thus maintains the transceiver in an inactive condition. Control circuit 112 is arranged to respond to an activation signal from activation receiver 102 by actuating clock circuit 113, and to close the circuit between power source 106 and transceiver 108 for a preselected initial period, desirably a few minutes, thereby activating the cellular transceiver for this initial period. The control circuit is further arranged to close the circuit between the power source and transceiver 108 intermittently after this initial period, so as to periodically activate the transceiver and thereby maintain the transceiver active on a predetermined duty cycle. The duty cycle may include a minute on followed by several minutes off. The transceiver operates to send a cellular telephone signal as discussed above during the initial period and again when it is turned on during the predetermined duty cycle. The off

periods in the predetermined duty cycle prolong the life of the power source. Clock 113 operates continually after receipt of the activation signal by control circuit 112. However, the power consumption of clock 113 is negligible by comparison to the power consumption of cellular transceiver 108 in the "on" state.

In a system and method according to further embodiments of the invention, the housing 120 of device 101 is attached to the a child 201 (Fig. 2) to be located in an emergency. In discussion of the system and method, device 101 is referred to as a "remote" device because it travels wherever the child to which it is attached travels. Child 201 is somewhere in a geographical region served by a cellular telephone system incorporating numerous geographical cells 216, delineated in broken lines in Fig. 2, each such cell having a cellular base station 215, also referred to as a cell site, within it. The cellular telephone system also includes a mobile telephone switching office or "MTSO" 220 linked to all of cellular base stations 215 in the conventional manner.

A guardian 204 having knowledge of the predetermined pager address used by the activation receiver unit 102 in device 101 can start the location process if he or she suspects that child 201 is abducted or lost. The guardian activates remote device 101 by dialing a pre-specified pager service number. The pager service number may place the guardian in contact with an operator at the pager center 205 so that the guardian can talk to an operator and provide the unique pager address of the particular remote device 101 which the child is wearing. Alternatively, the pager service number may establish communication with an automatic system at the pager center which allows the guardian to enter a particular sequence of telephone keys indicating the unique identification

number in an automated process. The guardian can initiate the location process from anywhere in the world by telephone.

Pager center 205 transmits the pager identification number via transmission signal 207 to one or more paging transmitters 209. As illustrated, paging transmitter 209 is disposed in a satellite orbiting the earth. Depending on the configuration of the paging system, the paging transmitters 209 could also be terrestrial transmitters mounted on radio towers. The paging transmitter or transmitters 209 send a wide-area radio activation signal 211 bearing the address of device 101 throughout a geographic area encompassing numerous cells 216. For example, where the paging transmitter is disposed on an earth satellite, the radio activation signal may cover one or more entire countries or continents. Likewise, a typical terrestrial paging transmitter in a city will cover all of the numerous cells in the city; using a typical paging network, the entire country can be covered by the radio activation signal. Alternatively, the paging system can be arranged to limit the area covered by the radio activation signal according to predetermined instructions associated with the pager address, to cover only those areas surrounding the child's normal location. Line 221 indicates a variable distance between pager center 205 and remote device 101; such distance could be thousands of miles or more depending on the paging network used. The distance could also be much less.

The radio activation signal 211 is received by the activation or paging receiver 102 of remote device 101. In the manner described above in connection with the description of Fig. 1, this receipt causes the activation receiver to provide the activation signal to control unit 112, which in turn activates the cellular transceiver unit 108. In the manner described above,

the forward control receiver 109 of unit 108 scans the forward control or "overhead" information transmitted from each cellular site 215 within signal range, selects the closest cellular site based on signal strength and extracts that cellular site identification code from the forward control information. The transmitter 109 in device 101 then transmits a cellular communication signal 213 including the preselected telephone number to be called and corresponding to the format of a standard cellular telephone call as in the manner described above. Upon setting up of the call, the transmitter transmits the identification of the device, the identification of the cellular system and the identification of the selected cell site 215 within this system. These transmission steps are completed extremely quickly, desirably within seconds or within a few minutes after guardian 204 initiates the process.

When the cellular network receives the communications signal at the selected cell site, the cellular network handles the call in the same manner as an ordinary call from a cellular telephone. Thus, the cellular communications network routes the call through MTSO 220 and through conventional telephone equipment to the telephone designated by the preselected telephone number carried by the cellular communication signal. This telephone is located at an emergency locating service center 217. Upon receipt of the call, the identification of the particular remote device 101, and the identification of the selected cell site 215, are communicated to the locating service center 217. At this point in the process, personnel at the locating service center are aware that the particular child associated with device 101 is in an emergency situation. Also at this point in the process, the location of device 101, and hence the location of child 202, has been determined to some extent; it is known that the child is within the particular geographic cell

216 associated with the selected cell site 215 of a particular cellular system. Center 217 may maintain a data base containing the physical location of all cellular systems and the cellular sites in each system, and may retrieve the geographic location of the cell site from the cell identification provided via the cellular signal. Location to this degree is useful in certain situations. For example, this degree of location will establish that a missing child is in a particular city and, in most cases, within a particular neighborhood.

More precise location can also be determined from the cellular signals transmitted by remote device 101. As discussed above, the transmitter portion 109 of the transceiver continues to transmit cellular signals on a preselected duty cycle, typically 2 minutes "on" and 8 minutes "off" after receipt of the radio activation signal. Law enforcement officers or others can be directed by personnel at center 217 to the particular cell 216 where the child is located, and can use conventional close-range direction-finding receivers to locate device 101 once in the vicinity of the identified cellular site. Also, many cellular telephone networks are equipped with emergency locating capability. Thus, the cellular network can actuate the receivers at several cell sites to detect a signal from a particular cellular telephone, and to determine the relative strengths and/or relative delay times of the signal as received at such sites. The location of the telephone can be determined with good precision from this data. Because the signal from remote unit 101 mimics a conventional cellular telephone call, the same emergency locating techniques can be employed to locate the remote unit.

In a system according to a further embodiment of the invention, control circuit 112 is arranged to actuate cellular transceiver unit 108 for only a short

interval in response to the activation radio signal; once the initial message is sent, the control circuit does not actuate the transceiver intermittently as described above. Thus, the transceiver sends the initial cellular call, which allows the system to identify at least the particular cell 216 where the child is located. When law enforcement officials or others searchers are within range of the identified cell, they actuate the paging system once again by signaling pager center 205 with a further telephone call bearing the address of device 101. The pager signal again activates the paging network to transmit the activation radio signal, whereupon cellular transmitter 109 in device 101 sends a new cellular signal for the same initial interval. This procedure can be repeated as needed. This arrangement conserves battery power; the cellular signal is only sent while the searchers are tracking the signal. The arrangements can be combined. Thus, the control circuit can be arranged to actuate the transceiver on the preselected duty cycle for a maximum transmission time, typically 1 hour and then deactivate the transceiver until another activation radio signal is received. This prevents depletion of the power source during a prolonged search effort.

Emergency locating center 217 may be the same center as pager center 205. Alternatively, the emergency locating center 217 can accept the initial guardian's call and have an operator or an automatic device activate the pager through pager center 205. Also, either the emergency locating center, the pager center or both can be part of mobile telephone switching office (MTSO) 220.

Figure 3 shows a block diagram of remote device 101' according to a further embodiment, with additional features added to the basic device described in Fig. 1. Device 101' includes a pager or activation

receiver 102', power supply 106', control circuit 112', clock 113' and cellular transceiver unit 108' similar to the corresponding components depicted in Fig. 1, together with antennas 104' and 110', a housing 120' containing these components and a bracelet 401 adapted to attach the housing to a child's arm or leg. Except as otherwise noted, these components operate in the same manner as discussed above. Device 101' further includes a switch 302 connected to control circuit 112'. Switch 302 is linked to a "panic" button 305 or actuator on the exterior of housing 120'(Fig. 4A) that can be pressed by the wearer of remote device 101'. This allows the child wearing the device to manually activate remote device 101' instead of waiting for pager receiver unit 102' to be activated by an incoming pager signal. The "panic" button will contain a safeguard against an accidental pressing of the button which activates remote unit 101' unnecessarily. Possible safeguards include a switch arrangement which requires pressing two buttons on opposite sides of remote unit 101 simultaneously, or a switch arrangement which requires a particular sequence of a plurality of smaller buttons to be pressed, or a physical cover that must be lifted in order to activate the "panic button". The "panic" button is preferably not included in remote device 101 when used by a small child. Thus if an older child is not yet discovered missing by his or her guardian, the locating process can begin when the "panic" button is pressed by the child. When switch 302 is closed, it provides an activation signal to control circuit 112'.

Bracelet 401 is equipped with a solid conductor 403 running through the complete length of the bracelet for security purposes. The bracelet 401' contains an inner core of strong material, such as steel, followed by conductor 403 and an outer covering of more flexible material (e.g., rubber). The bracelet

is fastened around the child's arm or leg, so that it cannot be removed by unauthorized persons without breaking or cutting it. Conductor 403 will be broken before the inner core is broken in any attempt to forcefully remove the bracelet. Also, the device includes a conductor 405 arranged within housing 120' so that the housing cannot be opened for access to the internal components without breaking conductor 405. Conductors 403 and 405 are connected to a sensing device 407. Sensing device 407 is arranged to provide an activation signal to control circuit 112' if either conductor 403 or conductor 405 is broken.

The control circuit reacts to the activation signals from switch 302 and from sensing device 407 in the same manner as it responds to the activation signal from activation receiver 102'. Thus, if the child activates the "panic button", or if any attempt is made to remove the device from the child, the control circuit applies power to cellular transmitter unit 108 and causes it to transmit cellular signals which allow remote device 101' to be located.

Device 101' further includes a homing signal transmitter 304 and associated antenna 306. Transmitter 304 is a low level transmitter of conventional design that transmits a homing signal that can be easily tracked within shorter distances. The homing signal from transmitter 304 can be used in addition to the generated cellular signals to find the exact physical location of remote device 101'. The homing signal transmitter may be arranged to generate signals more powerful than the maximum allowable cellular signal, so that the homing signal can be more easily tracked. The control circuit 112' may activate homing transmitter 304 at the same times as it activates cellular transceiver 108'. Alternatively, the control circuit can activate only homing transmitter 304, on a continuous or intermittent duty cycle, in

place of the cellular transmitter once the initial cellular call has been placed. In either case, the homing signal supplements the cellular call; the cellular call is used in the initial location phase of identifying the cell, whereas the homing signal is used to determine an exact location of remote device 101.

In a further variant, activation receiver or pager receiver 102' is arranged to recover data from an incoming activation radio signal in addition to the address encoded on the signal. Well-known common carrier paging protocols allow a page signal to carry data such as a telephone number to be called by the page recipient. Pager receivers can conventionally recover this data. Conventional common carrier paging systems allow a calling party, such as guardian 204 (Fig. 1) to specify data to be conveyed, as by entering numbers on a telephone keypad. Receiver 102' may be arranged to recover additional data encoded on an activation signal and to deliver such data to control circuit 112' in conjunction with the activation signal. The control circuit may be arranged to selectively activate either the cellular transceiver 108' or the homing transmitter 304 according to command signals sent as data on the activation radio signal or pager signal. Also, the length of time for which the cellular transceiver 108' and/or homing transmitter 304 is activated can be specified by such command signals. For example, the command signals can specify continuous operation or operation according to any desired duty cycle for either or both units 108' and 304. The command signals can also specify a telephone number to be called by unit 101'. Thus, the activation or page receiver 102' passes the telephone number to cellular transceiver unit 108', which encodes the specified telephone number on the cellular signal. The cellular telephone network will pass the call to the specified telephone number. This allows the device to work with

any of several locating centers. Where the cellular transceiver is adapted to work with different cellular systems using different protocols, the command signals may also specify one system to be used.

The housing 120' and bracelet used for remote device 101' will not interfere with normal hand or foot movement. They may be disguised as a watch. Alternatively, remote device 101 could be placed in a belt, jacket or other garment. The bracelet may contain portions of antenna 104', antenna 110' or antenna 306 to provide a longer antenna for better reception and transmissions. Also, antennas 104', 110' and 306 although depicted separately, could be implemented as a single antenna capable of detecting and transmitting signals of varied frequencies.

In the embodiment of Figs. 3 and 4, the remote device 101' can be activated manually by the child, or by operation of the removal or tampering sensors. In this case, the locating center 217 will receive the call bearing the identity of the device without any action by the guardian 204. The locating center checks the identity of the device against a database containing the guardian's telephone number and address for the child associated with each device, and calls the guardian for the child associated with the particular device which has been actuated. The locating center also calls the police to help locate the child in distress.

Although remote devices 101 and 101' have been discussed above with reference to a child as the object to be located, the same devices can also be attached to any other person or animal which must be located, such as an older person, mentally incompetent person, prisoner, wildlife animal or pet. These devices can also be attached to any inanimate object of value to be located if stolen, such as a car, fur coat, art, computers, boat or luggage. As shown in Fig. 5, a

device according to a further embodiment may include a housing 450 formed from a biocompatable material such as commonly used for implantable medical or veterinary devices. The housing contains the same elements as described above. The device according to this embodiment of the invention is attached to the object to be located, in this case an animal 452 or a human, by implanting the housing in the body of the animal, such as beneath the skin. Other forms of biocompatable housings include dental appliances and fillings implanted in the teeth.

The apparatus of Fig. 5 further includes an induction coil 454 disposed within the housing. The internal power supply of the device can be recharged by exposing the induction coil to a varying magnetic field to thereby transfer power to the coil without removing the device from the animal and without opening the skin. Other non-invasive power transfer devices, such as capacitive coupling devices can be used.

Additionally, the device of Fig. 5 includes an inertially driven generator 456 of the type used for providing electrical power to self-powered electronic wrist watches. Upon movement of the animal 452 or person in which the device is implanted, the generator charges the internal battery of the device. Other systems for deriving power from the body of the person or animal can be employed, such as thermoelectric systems which derive power from the temperature difference between the body and the surroundings. Where the device is carried outside of the object, solar cells can be used.

Apparatus according to a further embodiment is shown in Fig. 6. This apparatus includes a remote unit 101" similar to units 101 and 101' discussed above. This unit includes a power source, control circuit and cellular transceiver as discussed above. The housing 520 is secured to an object to be located,

in this case an inanimate object such as a work of art 522. Unit 101" includes a sensor 507 similar to sensor 407 discussed above in connection with Fig. 4A. Sensor 507 is connected to a conductor loop 505 embedded in the wall 506 of the building in which object 522 is housed. The object cannot be moved away from its assigned location without severing conductor 505. Sensor 507 thus will detect any movement of the object from its assigned position and provide the activation signal to the control circuit. Additionally, unit 101" incorporates a local signal receiver 509 and antenna 510. Local signal receiver 509 is adapted to receive radiant energy from a security system 513. The security system includes a transmitter 515 connected to a local antenna array 517 disposed at the doorway 521 of the building in which the object is kept. The security system emits a signal into the region within the local antenna array, in front of the doorway. The signal does not propagate through the remainder of the building. If object 522 is removed from the building through doorway 521, it will pass through the antenna array, whereupon receiver 509 will detect the security system signal and provide the activation signal to the control circuit of unit 101". In response to an activation signal from sensor 507 or from receiver 509, the control circuit will actuate the cellular transceiver as discussed above. In variants of this system, the device may include any conventional motion-detecting switch, such as a mercury switch or an inertial switch, instead of sensor 507 or in addition thereto for detecting movement of the object. Also, security system 515 can be replaced by a system which emits forms of energy other that radio waves, such as coded infrared signals. Receiver 509 and antenna 510 are replaced by a photodetector adapted to sense such signals. Further, receiver 509, or the corresponding photodetector, may be arranged to provide the

activation signal to the control circuit when the signal from the security system is absent. Thus, the security system is arranged to provide the radio or infrared signal throughout the area where the object is kept. If the object is removed from such area, it passes out of the range of the signal, and the receiver provides the control signal to actuate the device.

A device according to a further embodiment is mounted in a vehicle 600 (Fig. 7). The vehicle has a conventional engine, ignition system 604 and storage battery 606 with associated charging system (not shown) for providing on-board electrical power. The system includes an activation signal or page receiver 608, control circuit 610 and cellular transceiver 612 similar to the corresponding elements of the devices discussed above. The system also includes an independent self-contained power supply 614 and a global positioning system ("GPS") receiver 616. This receiver is arranged to accept signals from the Global Positioning System satellite network and calculate the position of the vehicle on the earth's surface, such as its latitude and longitude. As is well known, the GPS system can find position with an accuracy of about 20 meters or better. These elements desirably are mounted in a concealed location within the vehicle, and housed in a tamper-resistant enclosure. The system according to this embodiment further includes a numeric keypad 618.

Control unit 610 is connected to the vehicle storage battery 606, ignition system 604 and to keypad 618, as well as to the internal power supply 614 and the other elements of the system. Control unit 610 is arranged to generate an internal activation signal if the ignition system 604 is energized, unless a predetermined code, known only to an authorized driver, has been entered via keypad 618. The control unit and keypad thus detect unauthorized use of the vehicle and

provide the activation signal. Receiver 608 also responds to radio signals to provide the activation signal as described above. In either case, the control unit responds to the activation signal by supplying power to GPS receiver 616 and to transceiver 612, thereby actuating both of these units. The control unit attempts to supply power to the GPS receiver and to the cellular transceiver from the vehicle battery 606. However, if the connection to the vehicle battery has been severed, the control unit supplies power from the self-contained power supply 614. The cellular transceiver is activated in the manner described above to send a cellular signal compatible with the cellular telephone network. The GPS receiver provides data representing the geographical area in which the object is located, such as the latitude and longitude of the vehicle. This data is transmitted on the cellular signal by transceiver 612 and received by the locating center as part of the telephone call. Other devices for finding geographical location can be employed, such as LORAN, VOR, or inertial navigation devices. Also, the system on the object can include a device for deducing position from the forward control signals or other signals received by transceiver 612 from various cell sites. One such device is disclosed in Stilp et al., United States Patent 5,327,144. The GPS or other position-finding devices can be omitted where the cellular system includes location capability.

The system is not limited to the telephone as the sole way to communicate with pager center 205, but includes such methods as faxing the identification number, radio transmissions and others. Also, although the system has been described above with respect to a conventional cellular telephone network, other cellular communications networks can be employed. For example, the system commonly referred to as the "Personal Communications System" or "PCS" utilizes numerous low-

powered cellular base stations. The cellular transmitter incorporated in the device may be arranged to provide a signal compatible with any such system, i.e., a signal which can be received and handled by the system in the same way as a signal from a cellular telephone or other communications device normally used with the system. If the cellular system does not employ a forward control channel, the device need not incorporate the forward control channel receiver. Also, the radio signal used to activate the device need not be carried by a common-carrier paging network. For example, it can be broadcast directly from a dedicated wide-area transmitter, or broadcast as part of another radio signal such as a subcarrier signal on an FM channel or blanking-period information on a TV channel.

In a further embodiment, the power source of the device may includes two separate power sources, such as two batteries. One source provides low-level, long life power to the activation receiver or pager receiver. The other source provides a higher level of power for the cellular transmitter, but is activated by the control circuit only in response to the activation signal. Accordingly the energy in the second source or battery is conserved until required.

In the arrangements discussed above, the control circuit normally keeps the cellular transmitter and associated elements inactive by isolating these elements from the power supply. However, these elements may be continually connected to the power supply, and the control circuit may control these elements to hold them in an inactive state and activate them when required by actuating internal control devices within these elements.

The foregoing merely illustrates the principles of the invention. Those skilled in the art will be able to devise numerous systems and methods

which, although not explicitly shown or described herein, embody the principles of the invention and are thus within the spirit and scope of the invention.

INDUSTRIAL APPLICABILITY

The invention can be applied to protection of persons, animals and inanimate objects from abduction, theft or loss.

CLAIMS:

1. A device for locating an object within the service area of a cellular communications network, said service area being divided into a plurality of geographical cells, said network comprising a base station within each of said geographical cells, said device comprising:

(a) transmitting means for transmitting a radio signal compatible with said cellular communications network to one of said base stations identifying said object, said transmitting means being normally inactive; characterized by:

(b) activating means for activating said transmitting means in response to an activation signal provided independently of said cellular network, said activation means being normally active for receipt of said activation signal.

2. A device as claimed in claim 1 further characterized in that said activation means includes receiving means for receiving a radio signal from a radio transmitter separate from said cellular telephone network, said receiving means being normally active.

3. A device as in claim 2, further characterized in that said receiving means is adapted to receive said activation signal from a satellite.

4. A device as in claim 2, further characterized in that receiving means is adapted to receive said activation signal from a transmitter of a paging network.

5. A device as in claim 1, further characterized in that said activation means includes means for detecting movement of the device and providing said activation signal upon such movement.

6. A device as in claim 1 further characterized in that said activation means includes means for detecting passage of the device across a

boundary and providing said activation signal upon such passage.

7. A device as claimed in claim 6 further characterized in that said means for detecting passage of the device across a boundary includes means for detecting electromagnetic radiation.

8. A device as claimed in any of claims 1-7 further comprising a self-contained power supply, said activation means and said transmitting means being powered by said self-contained power supply.

9. A device as claimed in claim 8 further characterized in that said self-contained power supply includes a battery.

10. A device as in claim 8, further characterized by attaching means for attaching said transmitting means, said activating means and said power supply to an object.

11. A device as in claim 8, further characterized in that said transmitting means, said activating means and said power supply have a total volume less than about 200 cm^3.

12. A device as claimed in claim 8 further characterized in that said attaching means is operative to attach said transmitting means, said activating means and said power supply to the body of a person or animal.

13. A device as in claim 12 further characterized in that said attaching means includes a housing having a biocompatable exterior surface containing said transmitting means, said activating means and said power supply whereby said housing can be implanted in the body of a person or animal.

14. A device as in claim 13 further characterized in that said self-contained power supply includes non-invasive recharge means for accepting energy applied through the skin of the person or animal without opening the skin.

15. A device as in claim 13 further characterized in that said power supply includes means for deriving power from the body of a person or animal.

16. A device as in claim 10, further characterized in that said attaching means is operative to attach said housing to an inanimate object.

17. A device as in claim 9 further characterized in that said activation means includes means for detecting detachment of said housing from an object and providing said activation signal in response to said detachment.

18. A device as in any one of claims 1-7 further characterized by means for attaching said activation means and said transmitting means to a vehicle, said activation means including means for providing said activation signal in response to unauthorized movement of said vehicle.

19. A device as in any one of claim 1-7, further characterized by means for determining data representative of a geographical area within which said object is located, and further characterized in that said transmitting means is adapted to encode said data onto said cellular-telephone signal.

20. A method for determining the location of an object within the service area of a cellular communications network, said service area being divided into a plurality of geographical cells, said network characterized by a base station within each of said geographical cells, said method characterized by the steps of:

(a) placing on said object a radio transmitter, said radio transmitter being normally inactive;

(b) providing an activation signal independently of said cellular communications network;

(c) in response to said activation signal, activating said transmitter to transmit a

signal identifying said object compatible with said cellular communications network to one of said base stations;

(d) receiving said signal from said transmitter through at least one of said base stations; and

(e) determining said geographical location of said object from said received signal.

21. A method as claimed in claim 20 further characterized in that said step of providing said activation signal includes the step of broadcasting a radio activation signal, said step of activating said transmitter including the steps of operating a radio receiver on said object, receiving said radio activation signal at said receiver and activating said transmitter upon receipt of said radio activation signal.

22. A method as claimed in claim 21 further characterized in that said step of operating a radio receiver on said object includes the step of operating said receiver on a preselected duty cycle so that said receiver is on at for at least some portion of every hour.

23. A method as claimed in claim 22 further characterized in that, in said preselected duty cycle, said receiver is substantially continuously on.

24. A method as claimed in claim 21 further characterized in that said step of broadcasting said radio activation signal includes the step of broadcasting said radio activation signal from a wide-area radio transmitter throughout a geographical area characterized by at least a multiplicity of said cells.

25. A method as claimed in claim 24 further characterized in that said step of broadcasting said radio activation signal includes the step of

broadcasting said radio activation signal from a satellite in earth orbit.

26. A method as claimed in claim 24 further characterized in that said step of broadcasting said radio activation signal includes the step of broadcasting said radio activation signal from a public radio paging network.

27. A method as claimed in any one of claims 21-26 further characterized in that said step of operating a radio receiver includes the step of providing power to said receiver from a self-contained power supply on said object.

28. A method as claimed in any one of claims 20-26 further characterized in that said step of providing said activation signal includes the step of detecting motion of said object and providing said activation signal responsive to the so-detected motion.

29. A method as claimed in any one of claims 20-26 further characterized in that said step of providing said activation signal includes the step of detecting movement of said object out of a predetermined area and providing said activation signal responsive to the so-detected movement.

30. A method as claimed in any one of claims 20-26 further characterized in that said step of placing a radio transmitter on said object includes the step of attaching a device including said transmitter to said object, said step of providing said activation signal including the step of detecting detachment of said device from said object and providing said activation signal responsive to such detection.

31. A method as claimed in any one of claims 20-26 further characterized in that said object is a human or animal.

32. A method as claimed in claim 31 further characterized in that said step of placing a transmitter on said object includes the step of

implanting a device including said transmitter in the body of said human or animal.

33. A method as claimed in any one of claims 20-26 further characterized in that said object is a vehicle and said step of providing an activation signal includes the step of detecting unauthorized use of said vehicle and providing said activation signal responsive to such detection.

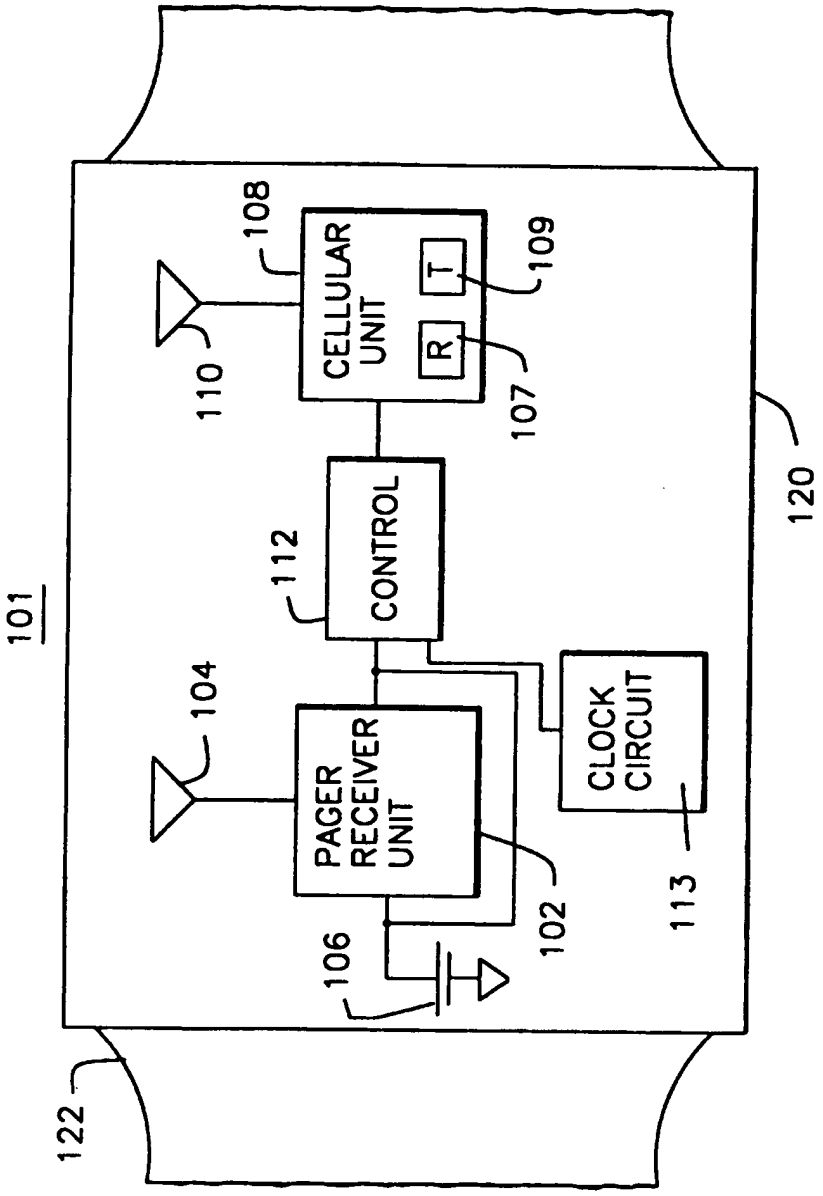
101
108
CELLULAR UNIT
T
R
109
107
110
120
112
CONTROL
104
PAGER RECEIVER UNIT
CLOCK CIRCUIT
102
113
106
122

FIG. 1

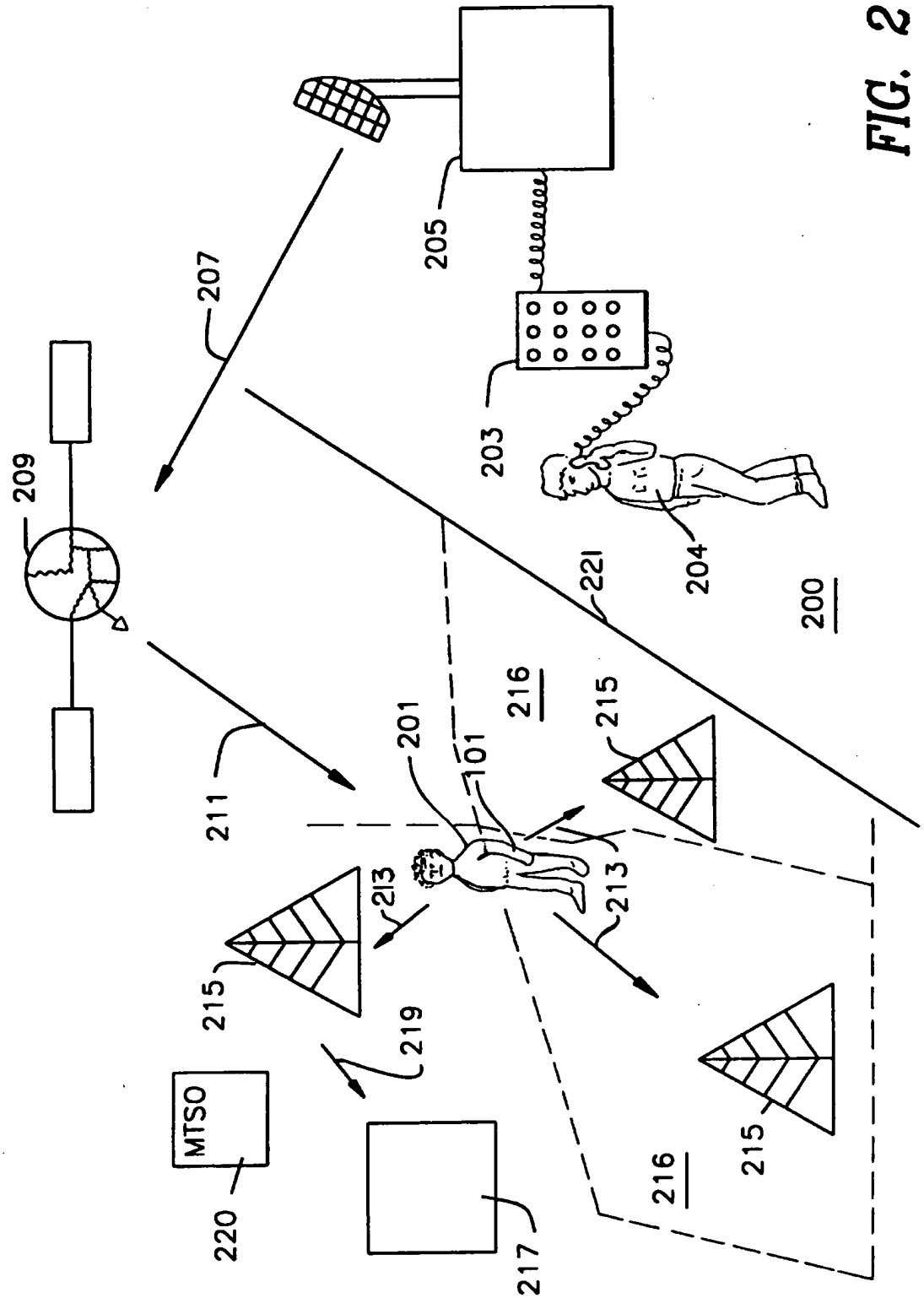
205
207
203
204
209
211
201
101
216
215
213
219
MTSO
220
217
221
200

FIG. 2

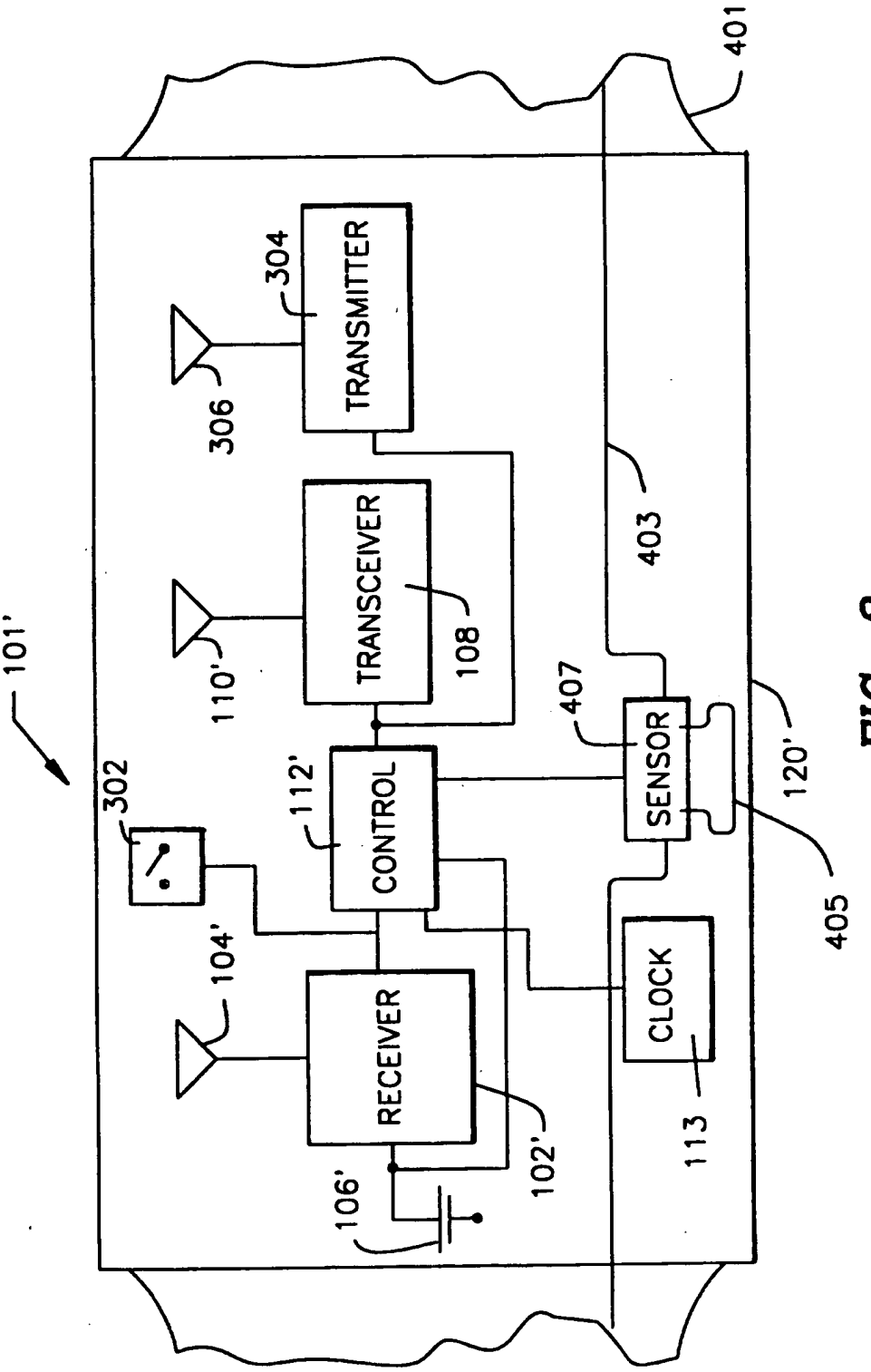
401
304
TRANSMITTER
306
403
TRANSCEIVER
108
110'
101'
407
SENSOR
120'
302
112'
CONTROL
405
104'
CLOCK
RECEIVER
113
102'
106'

FIG. 3

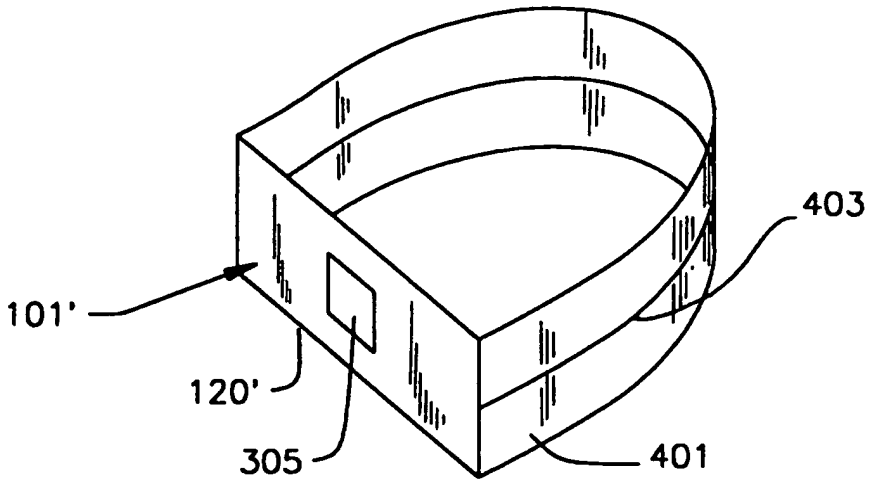

FIG. 4A

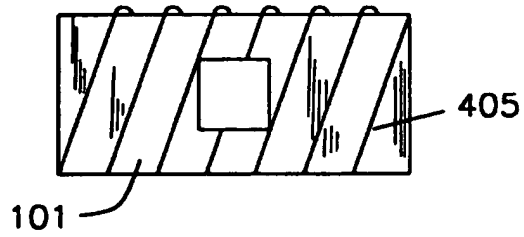

FIG. 4B

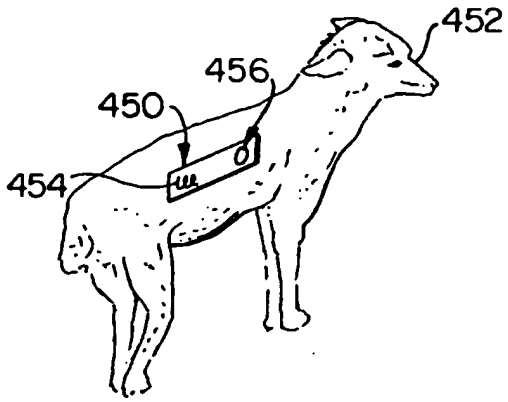

FIG. 5

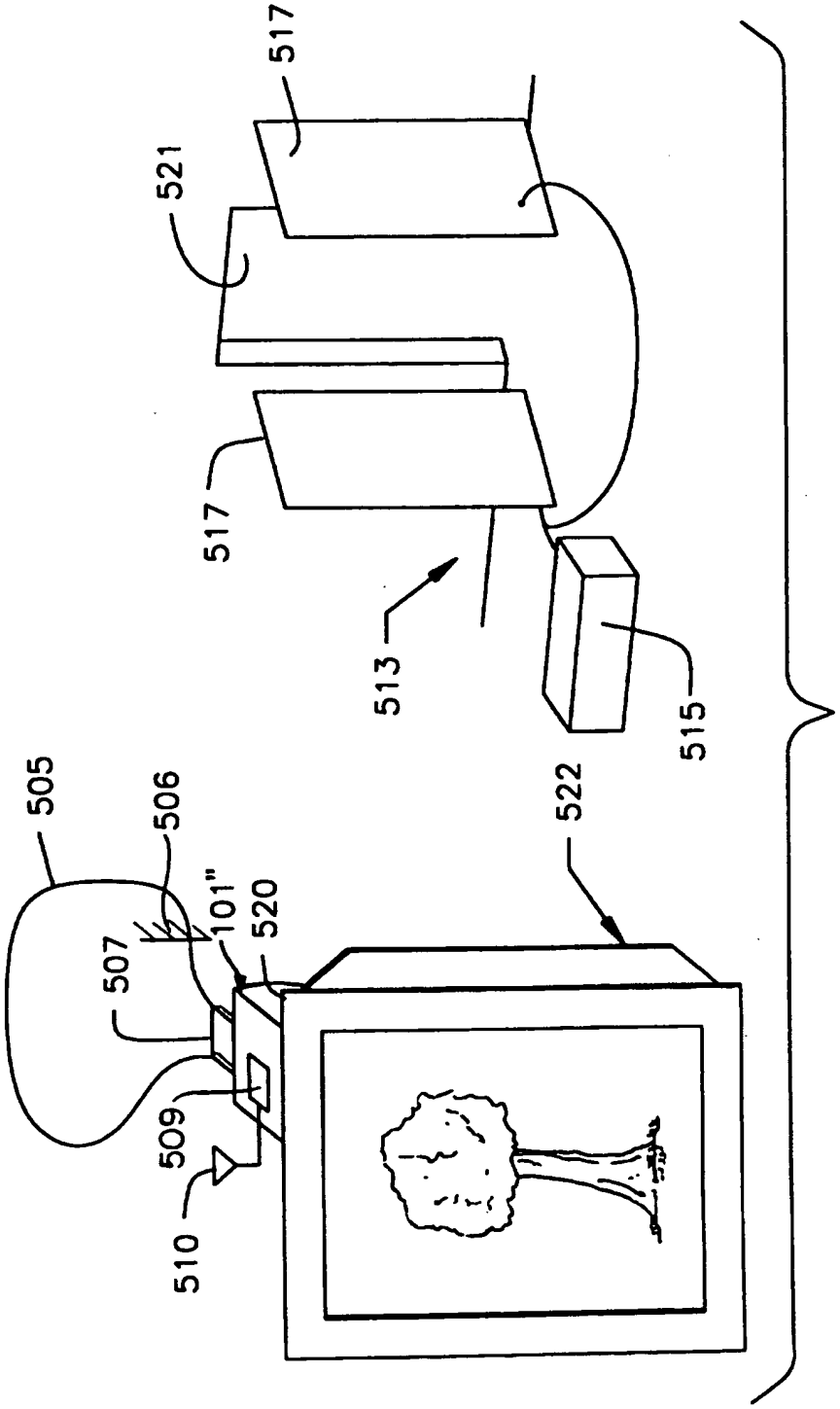

FIG. 6

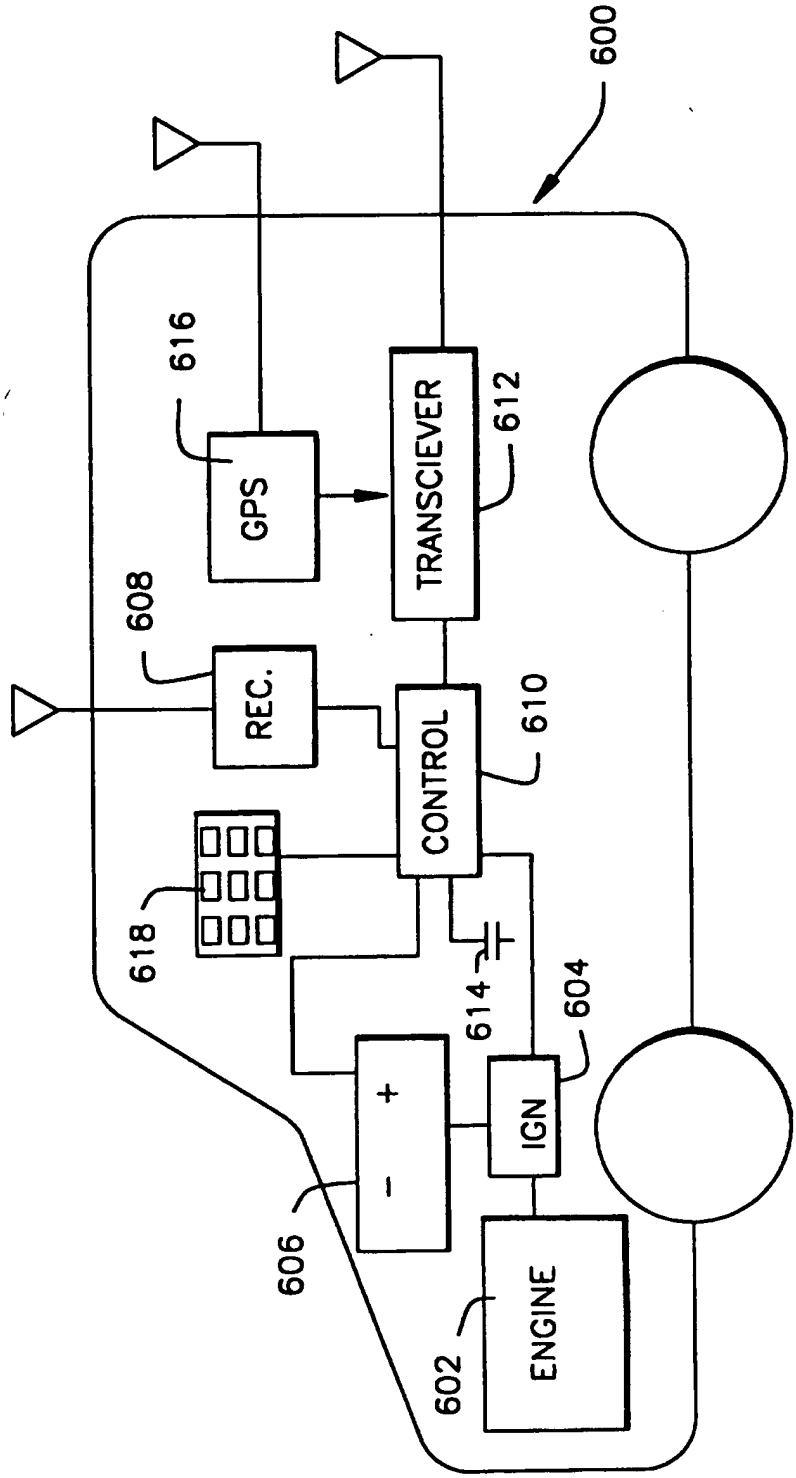
600
616
GPS
TRANSCIEVER
612
608
REC.
CONTROL
610
618
614
604
+
-
IGN
606
602
ENGINE

FIG. 7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US96/01917

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :H04Q 1/30; G08B 1/08; G01S 5/02; H04M 11/00

US CL :Please See Extra Sheet.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 340/311.1, 539, 825.49, 825.44, 825.69, 825.72, 379/56, 57, 58, 59; 342/350, 352, 450, 451, 357; 455/33.1, 38.1, 53.1, 38.3

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

NONE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

APS (CELLULAR TRANSCEIVER) AND TRACKING)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X/Y	US, A, 5,334,974 (SIMMS ET AL) 02 AUGUST 1994, FIGURES 1 AND 4; ENTIRE DOCUMENT.	1-3, 5-10, 12, 17--21, 24, 25, 27, 28, 30, 31, 33 / 11, 22, 23
X/Y	US, A, 4,750,197 (DENEKAMP ET AL) 07 JUNE 1988, FIGURES 1 AND 2; ENTIRE DOCUMENT.	1, 2, 5-10, 16-21, 24, 25, 27-30, 33 / 11, 22, 23
X/Y	EP, A, 0,242,099 (RAPOPORT) 21 OCTOBER 1987, FIGURE 1; ENTIRE DOCUMENT.	1-3, 5-10, 12, 16, 19-21, 24, 25, 27-29, 33 / 11, 22, 23

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be part of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search
20 APRIL 1996

Date of mailing of the international search report
21 MAY 1996

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Form PCT/ISA/210 (second sheet)(July 1992)*

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US96/01917

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US, A, 5,276,728 (PAGLIAROLI ET AL 04 JANUARY 1994, FIGURE 1; ABSTRACT.	4, 26
Y	US, A, 4,706,689 (MAN) 17 NOVEMBER 1987, FIGURES 2 AND 3, COLS. 2-4.	13-15, 32
A	US, A, 4,651,157 (GRAY ET AL) 17 MARCH 1987, ENTIRE DOCUMENT.	1-32
A	US, A, 4,742,357 (RACKLEY) 03 MAY 1988, ENTIRE DOCUMENT.	1-32

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US96/01917

A. CLASSIFICATION OF SUBJECT MATTER:
US CL :

340/311.1, 539, 825.49, 825.44; 379/56, 57, 59; 342/357; 455/33.1, 38.3